CHAPTER 9

NETWARE-BASED NETWORKING

After reading this chapter and completing the exercises, you will be able to:

- Identify the advantages of using the NetWare network operating system
- Describe NetWare's server hardware requirements
- Describe NetWare's memory, directory structure, and file system architectures
- Plan for and perform a simple NetWare server installation
- Explain how NetWare integrates with other network operating systems

ON THE JOB

A few years ago, I switched from a programming position to a network administrator position. I didn't know much about networks before making the change, but I realized that I wanted to do something other than type code for the rest of my life. One of my first projects was to install a NetWare 4.11 server for a school district. The new server would provide a centralized backup point for all files on the network. I figured the NetWare installation process would be painless, and I worried only about getting the backup software working.

I should have given more thought to the installation! My boss had provided me with an old, but powerful workstation to use for my new server. This workstation still had Windows 95 and a number of applications installed on its hard drive. I knew that I had to reformat the hard disk before installing NetWare. After doing so, I began the installation. Just as I chose the "install in English" option from the installation program, however, the screen went black. I could go no further. I reformatted the hard disk twice, but the same thing happened each time.

Finally I sought the help of a colleague who had many years of experience with NetWare. After I explained my problem, she smiled and confessed that she had once made the same mistake. NetWare's operating system, she told me, cannot be installed over the version of DOS used by Windows. Even though I had erased Windows and the applications from the hard disk, I hadn't erased enough. Instead, I had to install DOS 6.22, format the hard disk, and begin all over. Once I took these steps, the installation worked perfectly.

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As you learned in Chapter 8, a network operating system is software that resides at the highest layer of the OSI Model and manages resources on a server. In this chapter, you will learn about NetWare, another popular type of LAN and WAN network operating system. Windows 2000 Server and NetWare share many characteristics, such as their use of a centralized directory, graphical interfaces for management, and processor optimization techniques. Both provide file and print sharing in a client/server networking environment, and both enable you to use additional services such as remote access, Internet connectivity, and network management. As you will see, however, NetWare and Windows 2000 Server also differ in significant ways.

This chapter will not attempt to cover all of the details of installing, managing, and optimizing a NetWare networking environment. For that type of knowledge, and especially if you intend to pursue CNE certification, you should invest in a book devoted to Novell's NetWare. This chapter merely provides an overview of the requirements, characteristics, and basic structure of Novell's popular network operating system.

Introduction to NetWare

In 1983, Novell introduced its NetWare network operating system. At that time, Windows NT Server (the precursor to Windows 2000 Server) had not yet been developed and UNIX was used primarily to make applications available to clients, rather than share resources among clients. NetWare quickly became the operating system of choice for LANs and WANs, providing reliable file and print sharing services to millions of users. In subsequent years, Novell has refined NetWare so that it now includes support for TCP/IP, intranet services, a graphical user interface, and better integration with other operating systems.

Currently, several different versions of NetWare exist. Although versions 3.1 through 3.2 (collectively referred to as **NetWare 3.x**) were introduced in the early 1990s, some network administrators have not replaced their NetWare 3.x installations with newer versions because of the 3.x version's high reliability. You may find NetWare 3.x still running in cost-conscious organizations such as schools or nonprofit agencies, because these organizations cannot justify upgrading their network operation systems to a newer version.

Novell introduced NetWare 4.0, 4.1, and 4.11 (collectively known as **NetWare 4.x**) in the mid-1990s. NetWare 4.11 is sometimes referred to as **IntraNetware** because it was the first version of NetWare to support intranet services such as Web server software, IP address management, and FTP hosting. Novell changed the look of its network operating system with NetWare 4.x in an attempt to make this software more user-friendly, replacing most of the old DOS-based commands with a graphical user interface. In fact, many 3.x commands were replaced with new commands in version 4.x. NetWare 4.x also provided much better support for enterprise-wide networks containing multiple servers.

In 1998, Novell released version 5.0 of NetWare, and since then has released versions 5.1 and 5.11; collectively, they are known as **NetWare 5.x**. NetWare 5.x not only increases the extent and ease of network management, but also provides a network operating system wholly based on the IP protocol. As you know, the IP protocol is the de facto protocol of the Internet. In addition to being compatible with Windows 2000 and UNIX operating systems, NetWare 5.x offers flexibility and easy integration thanks to its use of IP. Another difference between NetWare 5.x and previous versions of NetWare is that many of its interfaces and services rely on the Java programming language. In addition, NetWare 5.x offers better printer and file system administration than version 4.x.

You do not need to know the specific differences between versions of NetWare to achieve Net+ certification. As a network administrator or technician, however, you will likely encounter environments that use one or several NetWare versions. This chapter focuses on

the most significant features of NetWare 4.x and 5.x, which are similar in use and design. Both use Novell Directory Services (NDS) to organize users, groups, servers, and other network resources. (You will learn more about NDS later in this chapter.) Both provide a graphical interface for managing network resources. In addition, both support integration with other network operating systems, Web services, multiple protocols, asset management, migration utilities, and software distribution. You can therefore use this chapter as a starting point in your exploration of NetWare.

Why Choose NetWare?

As you learned in Chapter 8, you need to answer some basic questions when choosing a network operating system.

- Can it be integrated with my existing infrastructure? (The infrastructure includes other network operating systems, and LAN topology, protocols, transmission methods, and connectivity hardware.)
- Will it provide the security required by my resources?
- Is my technical staff capable of managing it?
- Will my applications run smoothly on it?
- Will it accommodate future growth (that is, is it scalable)?
- Does it support the additional services required by my users (for example, remote access, Web site hosting, and messaging)?
- How much does it cost?
- What kind of support does the vendor offer?

Like Windows 2000 Server, NetWare offers excellent answers to these questions. In their fierce competition for the network operating system market, NetWare and Windows 2000 Server have both been forced to address the issues that cause the greatest concern for network administrators: performance, cost, flexibility, interoperability, and support. NetWare has been around for a long time and has a faithful following among network administrators. This popularity arises partly because some veteran networking professionals are more comfortable with NetWare, which was the first network operating system designed for file and print sharing. It also reflects NetWare's efficient processing, reliable services, and strong vendor support.

Like Microsoft, Novell can leverage its size to ensure that network applications are compatible and that support is easily accessible. Novell provides extensive online support from its support Web site, *www.support.novell.com*. From that Web page, you can search Novell's Knowledgebase, a database of technical information documents (TIDs), or join a forum in which networking professionals from around the world share their experiences with Novell products. You can also learn about known bugs in different versions

of NetWare and find explanations of common problems at the Novell support site. In addition, the company provides enhanced technical support to Certified NetWare Engineers (CNEs) through CDs and discounted calls to Novell's help desk. As with Microsoft products, you can find a number of third-party discussion groups on the Web as well as technical manuals and books that focus on NetWare products.

As noted earlier, NetWare is flexible, efficient, and secure. One feature contributing to its flexibility is the ability to natively support many different protocols. NetWare 4.x supports IP encapsulated by Novell's native IPX, and NetWare 5.x supports the use of pure (not encapsulated) IP. Both versions support the AppleTalk, IPX/SPX, and TCP/IP protocols, and both can handle Ethernet or Token Ring networks. Another advantage of NetWare is its ability to run multiple services simultaneously and use as many as 32 internal processors. Its modularity allows the network administrator to isolate some processes from others or change the priority of critical applications. For instance, if your NetWare server runs mail services, file services, and printer services for just one printer, you can make the print service have a lower priority than the mail and file services.

In addition to supporting a number of protocols and permitting quick configuration changes, NetWare offers native interoperability solutions for Macintosh-, Windows-, DOS-, OS/2-, and UNIX-based systems. To improve security, it provides encryption and other security measures to prevent intruders from hacking into the server or its resources.

In addition, both NetWare 4.x and 5.x supply graphical interfaces for managing network resources, including users, printers, groups, profiles, and shared drives. You can use NetWare's graphical interface from any workstation on the network. NetWare 5.x also provides a graphical server console based on the Java programming language, called ConsoleOne. In addition, version 5.x provides graphical wizards for part of the server installation. In versions lower than 5.x, you must install and configure NetWare servers entirely through DOS-based commands and menus. This requirement could be considered a drawback for less experienced network administrators.

Like Windows 2000 Server, however, NetWare does not necessarily suit all organizations. For example, if your organization depends heavily on enterprise-wide Microsoft solutions, such as SQL Server or Internet Information Server, you may want to forego a NetWare purchase. Although NetWare offers graphical interfaces for both management and console functions, one could argue that they are less intuitive than the Microsoft graphical interfaces since the Windows GUI is generally better recognized. If members of your technical staff prefer a simple, familiar graphical interface, Windows 2000 Server may therefore be a better choice.

Another difference between NetWare 4.x and Windows 2000 Server is that NetWare 4.x (and lower versions) cannot support virtual memory. Instead, it can use only the physical memory installed in the machine. Although this feature means that the operating system accesses memory more quickly, it does not allow the operating system to draw on extra hard disk space when physical memory becomes limited. Note, however, that you can use virtual memory with NetWare 5.x.

Ideally, you should test your critical applications (including network management functions such as backup and restore services) on all types of operating systems (NetWare, Windows 2000, and UNIX) to determine which will work most efficiently in your environment. Nevertheless, you probably will not have the luxury of designing a network from scratch and being the person who picks the network operating system. As mentioned in Chapter 8, the network operating systems that run on your servers will likely depend on political and technical issues in your environment or current business trends.

NetWare Server Hardware

You have learned that servers generally require more hard disk space, memory, and processing power than do client workstations on the network. Servers may also boast redundant disk drives, NICs, or power supplies or multiple processors. The more components you install on a server, the more expensive the machine. At the same time, however, the machine will likely operate more reliably and quickly with the added components.

Table 9-1 lists the minimum hardware requirements for versions 4.1 and 5.0 of NetWare, as outlined by Novell. If you plan to run applications or certain services on NetWare, such as a Web server or software distribution service (a network management function that was introduced in Chapter 1), your server will need more than these minimum requirements.

Table 9-1 Minimum hardware requirements for NetWare 4.x and 5.0 servers

Component	NetWare 4.x Requirement	NetWare 5.0 Requirement
Processor	An IBM or IBM-compatible PC with a 386sx, 486, or better processor. Out of the box, NetWare 4.x can support as many as 32 processors.	An IBM or IBM-compatible PC with Pentium processor. Out of the box, NetWare 5.0 can support as many as 32 processors.
Memory	20 MB RAM (the number should be increased for better performance; 64 MB is recommended).	64 MB RAM (the number should be increased for better performance; 128 MB is recommended).
Hard Disk	IDE or SCSI hard disk with at least 15 MB DOS partition and at least 75 MB NetWare partition.	IDE or SCSI hard disk with at least 50 MB DOS partition and at least 550 MB NetWare partition.
NIC	A NIC that supports your network type and for which you have drivers available.	A NIC that supports your network type and for which you have drivers available
CD-ROM	A model that can read ISO 9660 formatted CDs is recommended.	A model that can read ISO 9660 formatted CDs is recommended.
Pointing device	Optional.	Optional, but necessary if you want to use the GUI console.
Floppy disk	Optional, but a 3.5" floppy disk drive is useful for installing the NetWare operating system license.	Optional, but a 3.5" floppy disk drive is useful for installing the NetWare operating system license.

As you learned in Chapter 8, most networking environments actually require servers that far exceed the minimum hardware requirements suggested by the software vendor. Every situation will vary, but to determine the optimal hardware for your server, you should consider the following:

- How many clients will connect to the server?
- What kinds of applications will run on the server?
- How much storage space will each user need?
- How much down time is acceptable?
- What can your organization afford?

Perhaps the most important question on this list refers to the types of applications that the server will run. As is the case with Windows 2000 Server hardware, you can purchase an inexpensive server that runs NetWare 5.x, but suffices only for file and print sharing. To accomplish more with your network, you will want to run applications on the server; you will therefore need a more powerful machine. Every application has its own processor, RAM, and storage requirements. Consult the application's installation guide to find out its specific requirements.

When considering the NetWare operating system requirements, you need to keep in mind the number of **NetWare loadable modules (NLMs)** used by each service. NLMs are routines that enable the server to run a range of programs and offer a variety of services, such as protocol support and Web publishing. Each NLM consumes some of the server's memory and processor resources (at least temporarily). For example, when you install NetWare out of the box, your server will run many critical NLMs. If you install Novell's GroupWise e-mail and scheduler software, the server may require another five NLMs. If you install Novell's BorderManager software, the server may require still another five or so NLMs, and so on. The amount of resources consumed by each NLM depends on the NLM's size and complexity.

Novell provides a worksheet to determine how much memory your NetWare server will require. This worksheet, which contains blanks in which you can enter your network's specifications (such as the number of users), can be found in your NetWare documentation or at Novell's Web site. Before you recommend buying or actually purchase memory for your NetWare server, you should consult this worksheet.

As with Windows 2000, you can add components to your NetWare server to enhance its fault tolerance and performance. The most popular additional components include multiple processors, extra RAM, multiple NICs, fault-tolerant hard disks, a backup drive, and an uninterruptible power supply. You will learn more about how such components enhance network performance and reliability in Chapters 13 and 14. For now, it suffices to know that you must carefully analyze your current situation and plans for growth before making a hardware purchasing decision. Remember—paying more for a dependable server can be economical if it prevents down time.

A Closer Look at the NetWare Operating System

By now, you have probably noticed many similarities between the major features of NetWare and those of Windows 2000. You'll discover even more similarities, as well as some differences, in their operating system details. This section compares and contrasts the various details of the NetWare, Windows 2000, and UNIX operating systems.

If you have forgotten any of the concepts discussed in Chapter 8, refer to the Key Terms list in that chapter to refresh your memory.

Multiprocessing

In versions 4.x and higher, NetWare supports the use of as many as 32 processors on one server. Like Windows 2000, it takes advantage of symmetric multiprocessing, in which tasks are equally distributed among the processors. As you learned in Chapter 8, multiprocessing increases a server's performance when the server runs several operations simultaneously. For servers performing many processor-intensive activities, having multiple processors is usually worth the investment in the extra hardware. You will learn more about analyzing and optimizing network performance in Chapter 13.

To use NetWare 5.x's multiprocessing capabilities, you simply install multiple processors in the server. The operating system will automatically detect and make use of these processors, whether 1 or 32 are present, without additional configuration. In lower versions of NetWare, you must load a symmetric multiprocessing (SMP) module to take advantage of multiple processors.

NetWare's Memory Model

Whereas NetWare 4.x can use only physical memory, NetWare 5.x can work with both virtual memory and physical memory. Remember that virtual memory is actually composed of RAM and hard disk space that can provide temporary memory. NetWare 5.x benefits from virtual memory because many of its services use the Java programming language, which has high memory requirements.

Like Windows 2000, NetWare 5.x dynamically (in other words, without intervention and only as necessary) manages its use of both physical and virtual memory. For example, if a printing service currently resides in physical memory but hasn't been accessed for two hours, NetWare 5.x can push it into virtual memory so that a critical Java application (such as one needed immediately for file backup services) can use the physical memory. When the contents of virtual memory are required again, NetWare moves the printing service back into physical memory; at the same time, it sends another process from physical memory to virtual memory to open up the desired space.

Since the United States lifted tariffs that had been imposed on memory imported from other countries in the mid-1990s, good-quality memory chips have become very inexpensive. Therefore, you should never force your server to rely on the slower virtual memory to handle its typical processing loads. If the server suffers from too little physical memory and must spend all of its time swapping data to virtual memory, it will have no time to accomplish useful work.

NetWare, like Windows 2000, uses 32-bit addressing to provide quick access to the physical memory. It also allows you to run services in a separate memory area from the operating system, which prevents one rogue routine from taking the server down. Assigning a separate memory area to a service is known as running the service in **protected mode**. Protected mode prevents the service and its supporting routines from harming critical server processes.

In NetWare, you can generally customize the extent to which applications are isolated from one another in memory. Many of the core components of the NetWare operating system run in protected mode by default. The only services that cannot run in protected mode are those that must directly access the server hardware. In fact, Novell allows network administrators to adjust the server's use of memory in a number of ways. This flexibility can be both a blessing and a curse, however. If you change a setting in the wrong direction, for example, you may restrict the server's ability to process requests efficiently. Nevertheless, every environment will require some fine-tuning to maximize the use of memory, and every organization's memory needs will vary.

Although you can customize memory on a Novell network, both NetWare 4.x and 5.x manage physical memory very efficiently right out of the box. One important technique for managing memory is caching. **Caching** is the process of saving frequently used data to an area of the physical memory where it will be readily available for future requests. Caching accelerates the process of accessing the server because the operating system does not have to search for the requested data on the disk.

Conceptually, caching is similar to what goes on at a help desk. If 90% of the time a company's users call the help desk to ask questions about e-mail, the help desk manager might decide to publish a Web site giving answers to frequently asked e-mail questions. This Web site resembles a cache in that it provides commonly required information in an easy-to-access form.

The more physical memory that is present in your server, the more space the server can use for caching. On the other hand, the more services and applications run by your server, the less space the server will have for caching. As with most other memory settings in NetWare, you can change Cache Read and Write parameters to suit your environment.

The Kernel and Console Operations

At the heart of NetWare lies the **kernel**, or the core of the operating system. NetWare's 32-bit kernel is responsible for overseeing all critical server processes. The program SERVER.EXE runs the kernel from a server's DOS partition. Typically, a server will start by activating an AUTOEXEC.BAT file that launches SERVER.EXE; from that point

forward, NetWare controls the machine's operations. SERVER.EXE loads the critical NLMs that the kernel needs to run the NetWare operating system. In fact, once an NLM loads into memory, it is considered part of the kernel.

You can envision the kernel as a train with multiple cars. A train may leave Duluth with an engine, two tank cars, and five freight cars. These eight pieces, collectively, make up the train. In St. Paul, the train may pick up four more tank cars and six more freight cars. Now the train contains 18 pieces. If the train stops in Dubuque to deliver (or unload) five cars of iron ore, it does not fundamentally change. It will always need an engine, and no matter how many cars it carries, it remains a train. Much in the same way, NLMs can be loaded and unloaded (either automatically, by a program that requires them, or manually, by a network administrator) based on whether the kernel needs them. Loading and unloading NLMs does not change the kernel, however. The ability to dynamically load and unload NLMs makes the kernel modular and efficient. It also affords network administrators comprehensive control over their network operations.

The network administrator's primary interface to a NetWare server is the **server console**. Unlike in Windows 2000, this interface is not entirely graphical. NetWare 4.x employs only text-based server menus at the console. In NetWare 5.x, however, commands can be accessed through either a text-based or graphical menu system. The graphical interface in NetWare 5.x is called ConsoleOne.

Figure 9-1 illustrates a typical text-based console screen on a NetWare 5.x server. This console is launched from an NLM called Monitor. **Monitor** enables the system administrator to view server parameters such as protocols, bindings, system resources, and loaded modules. In many cases, it also allows the system administrator to modify these parameters. If you plan to specialize in NetWare administration (no matter which version of NetWare is involved), you should become very familiar with the Monitor NLM.

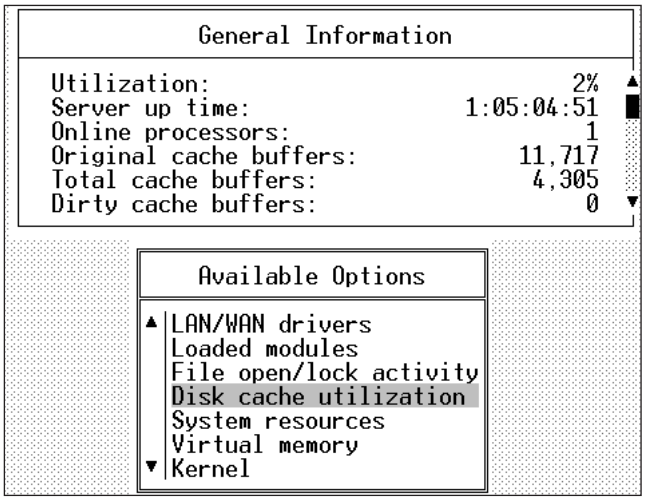

Figure 9-1 A NetWare console screen at the Monitor menu

Hundreds of NLMs are available for the NetWare operating system. In fact, developers can write their own NLMs for special purposes because Novell shares its operating system code. Nevertheless, you probably won't write your own, because most of the NLMs you'll ever need will come with your server software or the additional utilities you install.

You can view the NLMs currently running on your NetWare server by typing `modules` at the NetWare server console. To find out more about a single NLM, type `help` *XXX,* where *XXX* is the name of the NLM. For example, to find out more about the Monitor command, type `help monitor` at the console prompt. The server will respond with an explanation of the purpose of the command, its syntax, and its switches.

The NetWare server console prompt is not the same as a DOS prompt (which, among other things, allows you to view, copy, or delete files and directories on a computer). The purpose of the console is not to manage the file system, but rather to manage the server parameters. To manage the file system, you should log on to the server as an administrator from a workstation connected to the network. The next section discusses the NetWare file system in more detail.

The NetWare File System

As you learned in Chapter 8, a file system is an operating system's method of organizing, managing, and accessing its files through logical structures and software routines. NetWare does not allow you to specify the file system types in the same way that Windows 2000 does, but it offers its own high-performance file system that supports DOS, Macintosh, UNIX, OS/2, and Windows. Whereas the operating system supports DOS filenames by default, achieving support for other filenames (from other OSs) requires loading the proper NLMs on the server. Once you have installed the necessary modules, Macintosh, Windows, UNIX, or OS/2 clients can read from the server as if the server were running the Macintosh, Windows, UNIX, or OS/2 operating system, respectively. Because NetWare uses modules rather than file systems to support access by other operating systems, file/directory size limitations and performance do not vary between NetWare volumes or servers.

Like Windows 2000, NetWare uses volumes as the basis for organizing files and directories on the server. When you install NetWare, a volume called SYS is automatically created. At the time of installation, you may choose to create additional volumes such as DATA (for user data) or APPS (for shared applications), as well. (You should make additional volume names short, simple, and descriptive.) You should design the file system so that it meets your performance, security, growth, and data sharing goals. For example, by assigning all user data to its own volume called DATA, separate from the SYS volume that contains system files, you can protect your system files from accidental deletion. Creating a separate DATA volume for data files therefore provides more security than putting all data and system files on one volume.

Plan carefully before establishing a server's volume and directory structure—once established, they are very difficult to change. When installing a NetWare network from scratch, you should consult resources that can guide you through the process of planning the volume and directory structure for your network.

After planning and creating your server's volumes, you must determine whether the network should take advantage of NetWare's file compression capabilities.

Compression

NetWare 4.x and 5.x both support file compression, which is performed on a file-by-file basis. In other words, each file is compressed separately; an entire directory or volume is not compressed at the same time. Another feature of NetWare's file compression is that the processes of compression and decompression are transparent to the user. For example, if a directory containing e-mail has been compressed, a user who requests data from that directory will never know that, during the few seconds she waits to pick up the e-mail message, it is being decompressed.

In both NetWare 4.x and NetWare 5.x, unless the network administrator specifically chooses to prevent compression, compression on the server is enabled automatically. The average overall degree of compression attained by a NetWare 5.x server is 63%. Thus a 4 GB volume with 1 GB of uncompressed data and 3 GB of free space could gain 630 MB of extra free space (for a total of 3.63 GB free space) with normal compression. The compression ratio will vary for each file.

Compression does increase file access time slightly; for this reason, it is not recommended for extremely large files. NetWare will not compress files that exceed 256 MB in size. If you choose to use compression on your server, you'll find that NetWare provides numerous options for optimizing disk compression. Among other things, you can instruct the server to wait a specific period of days before first compressing new files, and you can disable compression altogether for some types of files or directories. You can also set a threshold of compression below which the operating system will not compress files. For example, if you specify that a very large database can be compressed by only 10%, it may not be worthwhile to compress it, because it would increase file access time and provide little space savings.

Some applications, such as older DOS-based databases, may not work when compressed on a NetWare server. Although the NetWare operating system can determine which of its own files can be compressed safely, you should verify that other system files and applications will work when compressed.

Block Suballocation

Block suballocation is a technique for using hard disk space more efficiently. To understand block suballocation, you must understand how data are stored on the hard disk. As you learned in Chapter 8's discussion of FAT32, each file on a computer is placed into one or more allocation units, or **blocks**, on the hard disk. (You can configure the standard block size on your server.) Normally, if an entire file does not fit into one block, it will consume as many blocks

as required to meet its storage requirements, even if it doesn't use all of the space in every block. For example, suppose your block size is 4 KB. A 17 KB file would require five blocks, or 20 KB of hard disk space, as pictured in the left-hand side of Figure 9-2. This arrangement wastes 3 KB of space.

Suballocation allows you to break blocks into smaller pieces, or suballocation blocks, of 512 bytes. If a file exceeds a whole number of blocks, it will use parts of additional blocks in increments of 512 bytes. The 17 KB file in the previous example would therefore use only 4.25 blocks, as shown in the right side of Figure 9-2. Other files can then occupy the remaining 3 KB piece of the fifth block. In this way, block suballocation permits you to use much more of the available space on the server's hard disk.

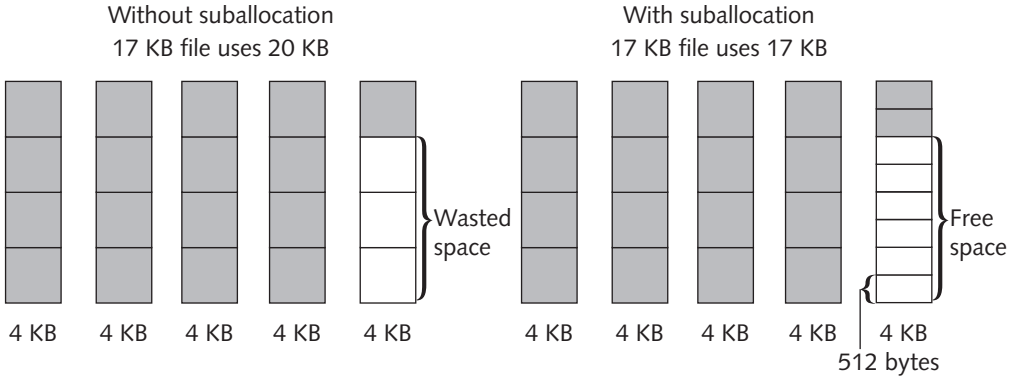

Figure 9-2 Block suballocation

Block suballocation is enabled by default when you install NetWare. To prevent block suballocation, you must deselect this option during a custom installation. Once block suballocation is activated on a volume, you can deactivate it only by reinstalling the server software (that is, NetWare).

NDS

NetWare Directory Services is a major development that Novell introduced with version 4.0. **NetWare Directory Services (NDS)** provides a system for managing multiple servers and their resources, including users, volumes, groups, profiles, printers, and so on. (In NetWare versions below 4.0, the Bindery contained this information.) The NDS model is similar to Active Directory in Windows 2000 Server. NDS treats every networked resource as a separate object with distinct properties. Each object can then be centrally managed from a single interface.

To understand how NetWare 4.x and 5.x work, you must first understand NDS. This section introduces the principles of NDS. Although it sounds like a simple concept, NDS can have a very complex implementation in large organizations. For more details on

designing and managing NDS structures, you should consult the NetWare documentation or purchase a book devoted to the topic of NetWare administration.

The NetWare installation process for the first server in a network generates the network's initial NDS. When adding servers or other resources to the network, you build upon this original NDS in a hierarchical fashion. Novell uses the analogy of a tree to describe this hierarchical layout. The **NDS tree** is the logical representation of resources in a NetWare enterprise. As with Active Directory's domain tree, the NDS tree is upside-down, with a single root at the top and multiple branches at the bottom, as shown Figure 9-3.

The NDS tree can have only one root, which is created during the first NetWare (4.x or higher) server installation on the network. Once created, the root cannot be moved, deleted, or renamed. Consequently, before you begin a NetWare 4.x or 5.x installation, you should meticulously plan your NDS structure and make sure that all decision makers in your Information Technology department agree on its naming convention.

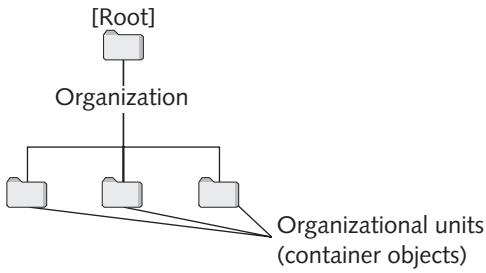

Figure 9-3 A simple NDS tree

The root leads to a hierarchical arrangement of branches. As in the Windows 2000 Server's Active Directory, these branches are called **container objects** (or **organizational units**) because their purpose is to logically subdivide the NDS tree and hold other objects that belong together.

Container objects may organize users and resources by geographical location, department, professional function, security authorization, or other criteria significant to the particular network. For example, if the root of the Sutkin Manufacturing Company's NDS tree is called "Sutkin," the container objects may be called "Maintenance," "Inventory," "Packing," "Shipping," "Information Services," "Accounting," and so on. On the other hand, if Sutkin Manufacturing is a small company with only a handful of users and other resources in the Maintenance, Inventory, Packing, and Shipping departments, these users and resources may be grouped in a larger branch called "Operations" and departments within the "Operations" container may be distinguished through the use of groups.

Figure 9-4 compares the various ways of grouping objects. For any organization, no single correct way to arrange an NDS tree usually exists. Instead, the organization of resources and container objects is a decision that network administrators must plan carefully.

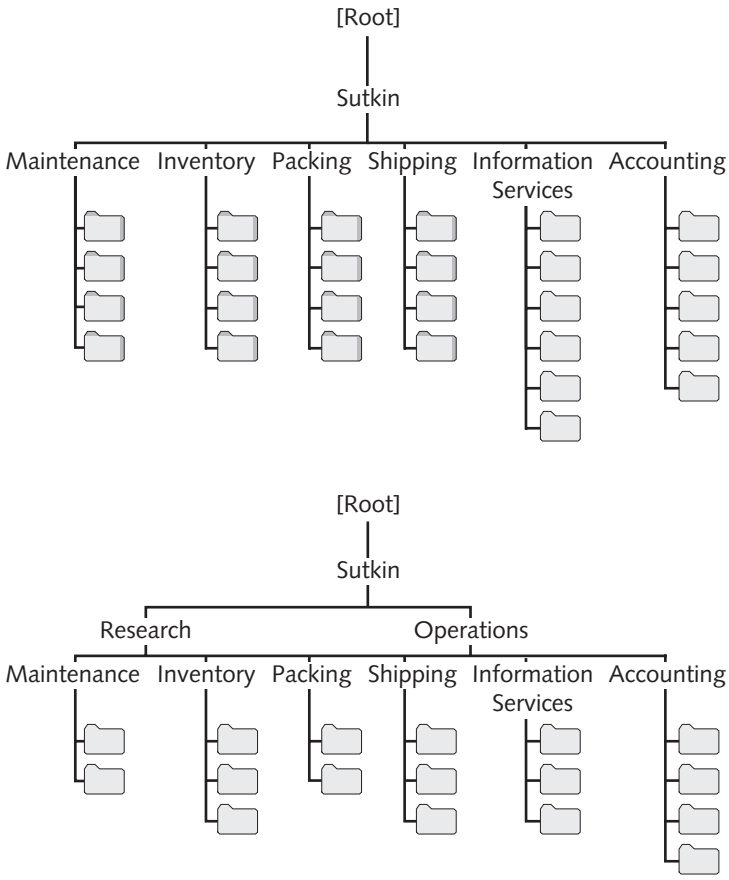

Figure 9-4 Two ways of grouping objects in an NDS tree

Moving away from the root of the tree, branch objects lead to either more branch objects or leaf objects. As you learned in Chapter 8, a leaf object is an object in the directory tree that does not contain other objects. For example, a print queue is a leaf object because it handles only the printer queue. A user is a leaf object because it does not contain or manage any objects other than the network user it represents. Several kinds of leaf objects exist. You will typically deal with user-related leaf objects such as users, groups, profiles, templates, and aliases or printer-related objects such as printers, queues, and print servers. Some Novell packages, such as ManageWise or ZenWorks, introduce other kinds of leaf objects into the tree. Nevertheless, all Novell products integrate with the NDS structure to allow easy, centralized administration. Figure 9-5 depicts a more complex NDS tree with several branch and leaf objects. (Compared to a real-world NDS tree, this example is still greatly simplified.)

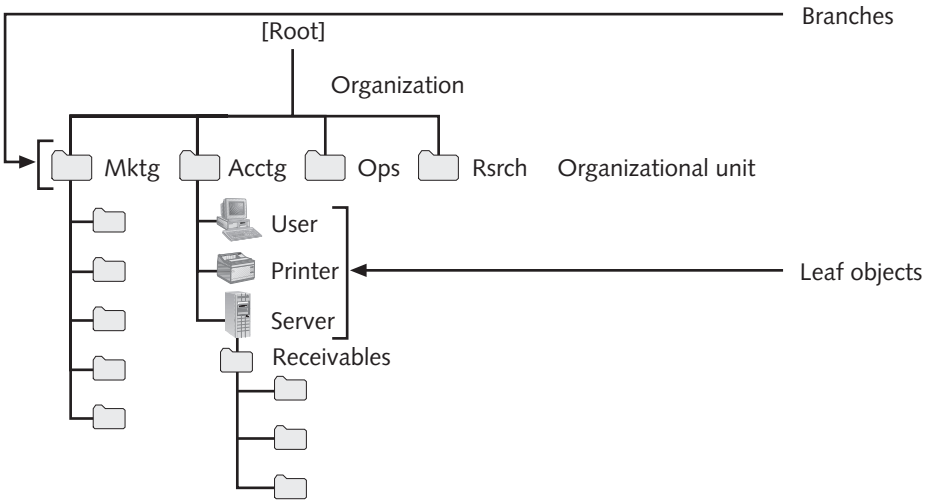

Figure 9-5 A more complex NDS tree

Each object in an NDS tree has a **context** that indicates where that object belongs in the tree. A context consists of an object's organizational unit names, arranged from most specific to most general, plus the organization name. Periods separate the organizational unit names within the context. You can envision the context as a kind of roadmap for locating an object.

Contexts may be expressed in two ways: typeful and typeless. The **typeful** notation is a relatively lengthy way of expressing context that includes identifiers for the organization and organizational units. For example, a user named Phil who works in the Receivables area of the Accounting ("Acctg") department of Sutkin Manufacturing in Figure 9-5 would have a typeful context of OU=Receivables.OU=Acctg.O=Sutkin. In this typeful context "OU" stands for "organizational unit" (another name for a container) and "O" stands for "organization" (which is associated with the root of your tree). A **typeless** notation eliminates the "OU" and "O" designations. In the preceding example, Phil's typeless context would be Receivables.Acctg.Sutkin. Both the typeful and the typeless contexts indicate that Phil is a member of the Receivables organizational unit, which is located in the Acctg organizational unit, which is part of the Sutkin organization.

In a large corporation with a complex NDS tree, a user's context can quickly become very long. Users do not always have to know or provide their context, however. Instead, the workstation support group or network administrator can configure users' client software to assume by default the context and the organization to which each user belongs. Users can then log on to their organizations with only a user name. In the preceding example, a user named Phil with the typeful context of OU=Receivables.OU=Acctg.O=Sutkin would simply type "phil" when prompted for his user ID.

Another significant similarity between Active Directory and NDS is the use of the word schema to refer to the set of objects (such as user or printer) and their attributes in an NDS tree. The simplest schema is the one that ships with NDS. A network administrator can extend the schema to include additional object classes and attributes. For example, you may want to add a user's fax number as an optional attribute. Think of the word *schematic* as it applies to a building design. An architect's schematic drawing might guide him in choosing which materials should be used for walls and doors, how a building should be positioned on a site, where gas and electrical conduits may be installed, and how old structures can be integrated with new additions. Similarly, the NDS schema serves as a reference for the logical design of your network.

Do not confuse NDS with the NetWare file system. The two are completely different entities. The file system pertains to the physical servers and the arrangement and maintenance of the data. NDS refers to the logical organization of servers and resources across an enterprise-wide network.

The NetWare operating system stores NDS information in a database format and distributes the information over several volumes. In larger organizations, NDS information may be distributed over several servers for two reasons: to accommodate its size and ensure its integrity. Conceptually, NDS does not appear to be tied to the server's hard disk. For example, the server does not have a big database file called "NDS.DB" that holds all of the tree and object information. In fact, NetWare keeps NDS information in hidden storage areas across (usually multiple) servers.

Typically, only network administrators have rights that allow them to modify the NDS tree. NDS management can be performed only through NetWare resource management tools, such as the NetWare Administrator utility. The **NetWare Administrator utility (NWAdmin)** is a graphical NDS management interface that can be launched from a Windows 9x or Windows 2000 workstation. Figure 9-6 shows an example of an NWAdmin screen with NDS objects. You will learn more about managing objects through NWAdmin later in this chapter.

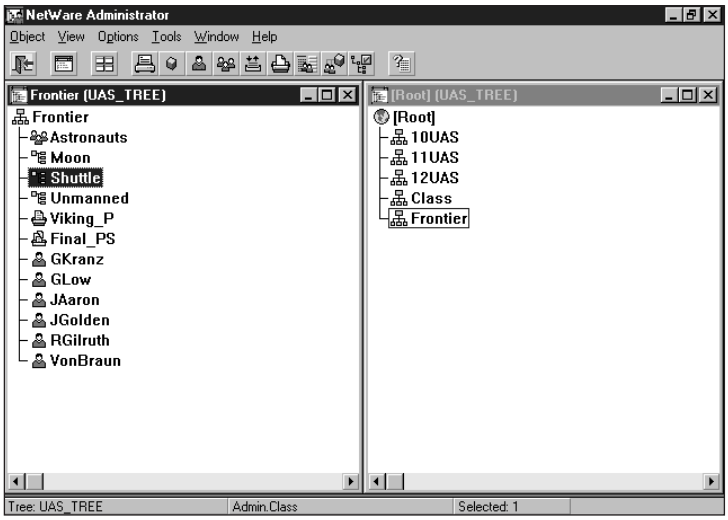

Figure 9-6 An NWAdmin interface

9

Installing and Configuring a NetWare Server

As with any major installation, you should first draw up a plan before beginning to install NetWare. Before you insert the NetWare CD into your CD-ROM drive, you should consider many factors, including the organization's structure, function of the server, server hardware, applications, number of users, LAN architecture, and optional services (such as Web hosting). As you learned in the discussion of Windows 2000 Server in Chapter 8, once you have installed and configured the network operating system, changing its configuration may prove difficult and perhaps cause service disruptions for users. This section provides an overview of the decisions you need to make when installing and configuring your NetWare server.

Planning for Installation

The importance of planning for installation cannot be overemphasized. Poor planning results in more work for the installer, potential down time for users, and headaches for whomever supports the server after installation. The following list summarizes the critical preinstallation decisions you should make. As you will see, the list is very similar to the decisions that you must make before installing Windows 2000 Server; where Windows 2000 deals in Active Directory, NetWare focuses on the NDS tree.

- *Where does the server fit in the NDS tree?* The place occupied by the server in your network's NDS tree (its context) will depend largely on its function. If this function is merely to allow a group of students to print to a classroom printer,

then the server might belong to a small organizational unit for that classroom. If the server will provide network access for all of the math instructors, it may belong in the Math container of your tree. If the server will provide mail services to the entire company, it may have its own organizational unit off the root of the tree called Mail. Clearly, you should develop your organization's tree and its policies for container and leaf objects before you begin installation. The server's place in the NDS tree will affect how easily it can be accessed and managed. Once you have established the server's context, you cannot change it.

- *What name will the server have?* Choose a practical, descriptive name that distinguishes the server from all other servers. You might use geographical server names, such as Boston or Buffalo. Alternatively, you might name servers according to their function, such as Marketing or Research. Bear in mind that the server name can (and usually will) differ from its NDS container's name. For example, the high school Math department server in a school system's NDS structure might be called "MATH_DEPT," but it might belong to the "Math" organizational unit, which might in turn belong to a larger organizational unit called "HS" under the school system's root.
- *How many and what kinds of network adapter cards will the server use?* Before you begin installing NetWare, you should have driver and diagnostics disks on hand for the server's NICs. The NetWare installation process will attempt to find your NIC's driver in its own collection of software, but it may not always be successful in this quest. You should therefore be prepared to supply the NIC software, and the NIC's IRQ, shared memory address, and I/O base address before beginning the server installation.
- *What protocols and network services should the server use?* You need to know which protocols your network requires. As you will recall from Chapter 3, more networks are moving toward TCP/IP-based transmission because this family of protocols is flexible, reliable, and widely supported. If your NetWare server will run Web services or connect to UNIX systems, for example, you must install IP. NetWare 4.x provides support for TCP/IP, whereas NetWare 5.x runs TCP/IP natively. By default, the NetWare 5.x installation process selects IP as a protocol that the server will support.
- *What kind of disk controllers does my server have?* NetWare's installation program will attempt to detect what kind of hard disk and CD-ROM drive your server possesses. If the program can correctly identify the hardware, it will install the drivers. Otherwise, it will prompt you to choose drivers from a list or install a driver from a disk. Either way, you should know what kind of disk controllers your server has (you can find this information in the server's hardware specifications). Note that the NetWare installation process does not always choose the right controller by default. NetWare can support SCSI, IDE, and ESDI hard disk controllers.

- *How many, how large, and what kind of volumes will the server require?* NetWare's installation program will ask you to identify the size, number, and names of the server volumes. Initially, the program assigns all free space on the hard disk to its default volume, SYS. To add volumes, you must modify the size of SYS (by subtracting the size of the other volumes you intend to create from SYS's current size).
- *What additional services will the server support?* You may choose to perform a custom or simple installation of NetWare, depending on the services and applications that your server will run. In a **simple installation**, the most popular installation options are chosen for you. This type of installation takes place more rapidly than a **custom installation**, which allows you to determine which services and programs should be installed, among other things. The first time you install a NetWare server (ideally, in a test environment), you will probably want to choose a simple setup to see how the installation process works. If you know the exact requirements for your environment and you feel comfortable with the NetWare installation process, you may choose to perform a custom installation. In that case, a list of additional services to install will appear near the end of the installation process. These services include support for Web and FTP hosting, backup utilities, OS/2 utilities, and TCP/IP address management. If you neglect to install a service during this process, you can always install it later.
- *What kind of license do I have?* When you purchased the NetWare operating system, you chose a licensing option for your organization. During the installation of the operating system, you will be prompted for the license diskette (or file, if you've copied it to the server's hard disk) that came with your NetWare software. NetWare licenses vary chiefly in terms of how many concurrent (simultaneously connected) users are supported by the server.
- *How can I remember all of this information?* Once you have made these decisions, you should create a server installation form and keep it with you during installation. Appendix C offers an example of such a form.

The preceding list highlights only the most significant installation options. You should also be prepared to read and accept the license agreement, identify your time zone, and specify an administrator account ID and password.

The Installation Process

After you have planned your installation, you can actually perform it. NetWare can be installed from a CD (the most popular method), floppy disks (not recommended), or another server on the network; the latter process is called an "over-the-wire" installation because the files are copied over the network's wiring. In this section, you can follow the steps to carry out a simple standalone NetWare 5.1 server installation performed from a CD-ROM. For simplicity's sake, this example uses the default installation options. You should perform a NetWare installation on a server that has a new installation of DOS version 6.22 or higher (do not attempt this installation from a DOS prompt on a server running a Windows operating system or from the DOS version that comes with Windows).

To perform a simple NetWare 5.1 installation:

1. Boot your server with a DOS system floppy diskette.
2. At the command prompt type **`FDISK`** to start the disk formatting utility. Follow the FDISK instructions to create a DOS partition that is at least 100 MB in size. Be sure to mark the partition Active (in other words, designate the partition as the one from which the server will boot).
3. After creating the DOS partition and making it active, exit the FDISK utility and restart the server (leaving the DOS system diskette in the floppy disk drive).
4. At the command prompt, type **`FORMAT C:/S`** to format the DOS partition with system files.
5. Install the necessary CD-ROM drivers to the DOS partition you have just created. Remove the DOS floppy diskette from the floppy disk drive and restart your computer.
6. Insert the NetWare 5.1 CD-ROM and change your working directory to the CD-ROM drive letter (typically, this is D: or E:).
7. At the CD-ROM command prompt, type **`INSTALL`**.
8. The NetWare Installation program starts, displaying a license agreement screen. Read the license agreement, then press **F10** to continue.
9. Press **Enter** to continue.
10. The next NetWare Installation screen prompts you to select a type of installation: upgrade or new server. For the purposes of this exercise, use the Enter key to select **New server** (if it is not already selected), accept the default installation of **\NWSERVER**, and then press **Tab** to move to the text menu window. Make sure the **Continue** option is highlighted in the text menu and press **Enter** to continue. The Server Settings screen appears.
11. The Server Settings screen contains NDS, Server ID, and Server boot options. Verify that NDS 8 is selected in the NDS version field. NDS 8 enables NetWare 5.1 to take advantage of new Web product support. The Server ID is a randomly generated 8-digit hexadecimal number unique to the server. Leave the Server ID as is. The Load server at reboot option allows you to choose whether the NetWare 5.1 software will load automatically when the server is restarted. Leave this option at its default, also.
12. Select **Continue** and press **Enter**. The Regional Settings screen appears.
13. Select **Continue** and press **Enter** to accept the default Country, Keyboard, and Code options in the Regional Settings screen. The Display and Mouse settings screen appears.

14. At the Display and Mouse settings screen, modify display or mouse settings as necessary, make sure the **Continue** option is highlighted, then press **Enter** to continue.

15. The NetWare installation program copies initial files to your server's hard disk. Next it attempts to identify the server's storage adapters, and present you with a screen that identifies drivers for the Platform Support Module, HotPlug Support Module, and Storage adapters. Make sure the device driver identified for the storage adapter matches your computer's storage adapter type. If it does not, modify the storage adapter device driver. When you have identified the correct storage adapter device driver, select **Continue** and press **Enter**.

16. The NetWare installation program attempts to identify the network adapter driver and displays the updated list of device drivers that it has selected for storage devices, network boards, and NetWare loadable modules. Make sure the drivers listed match your server's device types, then highlight **Continue** and press **Enter** to proceed to the next installation step.

17. After checking for free space on your server's hard disk, the NetWare installation program displays the Create a NetWare partition and volume SYS screen. By default, all free space on the NetWare partition is assigned to the SYS volume. For the purposes of this exercise, highlight **Continue** and press **Enter** to accept this default and continue. (In a more realistic situation you would reduce the default size of the SYS volume and allow free space to later create additional volumes on your server.)

18. The NetWare installation program begins copying files to the SYS volume. When it finishes copying, it launches a GUI interface that replaces the text-based menu screens for the remainder of the NetWare 5.1 installation process. The first GUI screen that appears is the Server Properties dialog box.

19. Enter the server name CLASS_TEST in the Server Name text box, then click **Next** to continue. The Configure File System dialog box appears.

20. Click **Advanced** to view the File System dialog box. Click **Mount Volumes** to make the volumes accessible to the server at this time, and then click **Next** to return to the Configure File System dialog box.

21. For the purposes of this exercise, click **Next** to accept the default of a single SYS volume on the server. The Protocols dialog box appears.

22. The Protocols dialog box allows you to specify and configure protocols for each network adapter in your server. Select the network adapter in the Network Boards list, then click in the **IP** check box to run the IP protocol on this network adapter.

23. Type an IP address of **198.76.54.21** in the IP Address text boxes. If necessary, type **255.255.255.0** in the Subnet Mask text boxes. Click **Next** to continue. The Domain Name Service dialog box appears.

24. The Domain Name Service dialog box contains text boxes to identify this server's host and domain name, as well as the IP address of the DNS server it will use to resolve its name to its IP address. Since this is a standalone server, leave the text boxes on this screen blank, then click **Next** to continue.
25. A message warning you that no host name or domain name has been specified appears. Click **OK** to respond to the warning message and continue.
26. The Time Zone dialog box appears. Choose your time zone and click **Next** to continue.
27. The NDS Install dialog box appears, asking whether you want to upgrade an existing NDS tree or create a new NDS tree. Click on the **New NDS Tree** option and click **Next**. The NDS Install dialog box appears.
28. Type **`Global_Corp`** in the Tree Name text box. Type **`Class`** in the Context for Server Object text box. If necessary, type **`Admin`** in the Admin Name text box. If it isn't automatically filled in, type **`O=Class`** in the Admin Context text box. Finally, type **`myglo889`** in the Password text box and retype the password in the Retype Password text box.
29. Click **Next** to install NDS and display a summary window containing the NDS context information. Record the information for later reference, then click **Next** to continue. The Licenses dialog box appears.
30. Insert the NetWare 5.1 license diskette that came with your NetWare 5.1 software into your server's floppy disk drive. Use the **Browse** button to locate the NLF license file in the floppy diskette's\license folder. Click **OK** to accept and install this license file.
31. After the license file is installed, click **Next** to display the Installation Options dialog box.
32. In the Installation Options dialog box, click the **Custom** option, then click **Next** to continue. The Components dialog box appears.
33. In the Components dialog box, click the check boxes next to **NetWare Enterprise Web Server** and **NetWare FTP Server** options to deselect these components. Verify that only **Novell Distributed Print Services (NDPS)** is selected, then click **Next** to continue.
34. The Novell Certificate Server 2.0 Objects dialog box appears. The purpose of the Novell Certificate Server is to enable support for secure data transmission by NetWare Internet services components (you will learn more about digital certificates in Chapter 15). Click **Next** to accept the default certificate server settings, then click **OK** to accept the Organizational Certificate of Authority warning message.
35. A Summary dialog box appears, listing the selected NetWare 5.1 products that will be installed, along with the amount of hard disk space each requires.

Verify that the listed information is correct, and then click **Finish** to initiate the main NetWare 5.1 file copy process.

36. Once the NetWare 5.1 software has been copied to the server, a Completion window appears. Click **Yes** to complete the installation and restart the server.

In actual practice, your NetWare installation will probably involve more decisions (particularly with regard to volume sizes and names, NDS context, and NetWare services to install) than indicated in this example. You may want to experiment with a simple installation such as this one, however, before you perform installations on your working servers.

After performing a NetWare 5.x installation and restarting the machine, your server should be functional. If you chose the simple installation, the TCP/IP protocol will be installed and bound to your NIC. To install other protocols at a later date, you must run a configuration utility from the console called inetcfg. Modifying the server's network properties through these commands is beyond the scope of this chapter. If you plan to become a NetWare expert, however, you should study the capabilities of the nwconfig utility.

After you have installed a NetWare server, verify that you can log on to that server as administrator from a Windows 2000 or Windows 9x workstation using the Novell Client for NetWare. If this effort fails, you may need to use the configuration commands to verify that the server has network connectivity.

By default, the NetWare installation process creates the NDS tree (if one didn't previously exist), a SYS volume, an administrator user called Admin who has supervisory rights to all objects in the NDS tree and all files in the file system, and a group called [Public] that has Browse rights to view all objects in the NDS tree.

Using the NetWare Administrator Utility (NWAdmin)

To make your server functional, you will need to add users and other objects to the NDS tree. After adding objects, you may want to modify their properties or even delete them. This section introduces an important tool in NetWare server management, the NetWare Administrator utility (NWAdmin). As explained earlier in this chapter, NWAdmin is a graphical interface that runs from a Windows workstation and enables network administrators to manage NDS objects. Through the use of drop-down menus and toolbars, it simplifies the process of viewing, creating, changing, and deleting objects.

The best way to learn about NWAdmin is to experiment with it on a test server. You will have such an opportunity in the following exercise and in a Hands-on Project at the end of this chapter.

To create objects in the NDS tree:

1. To manage the NDS tree through NWAdmin, you must have administrator rights. Log on to your NetWare 4.x or 5.x server from a Windows workstation as an administrator.

2. Launch the following executable file from your server's SYS volume: **PUBLIC\WIN32\NWADMN32.EXE.** The NetWare Administrator (NWAdmin) window opens, as shown in Figure 9-7.

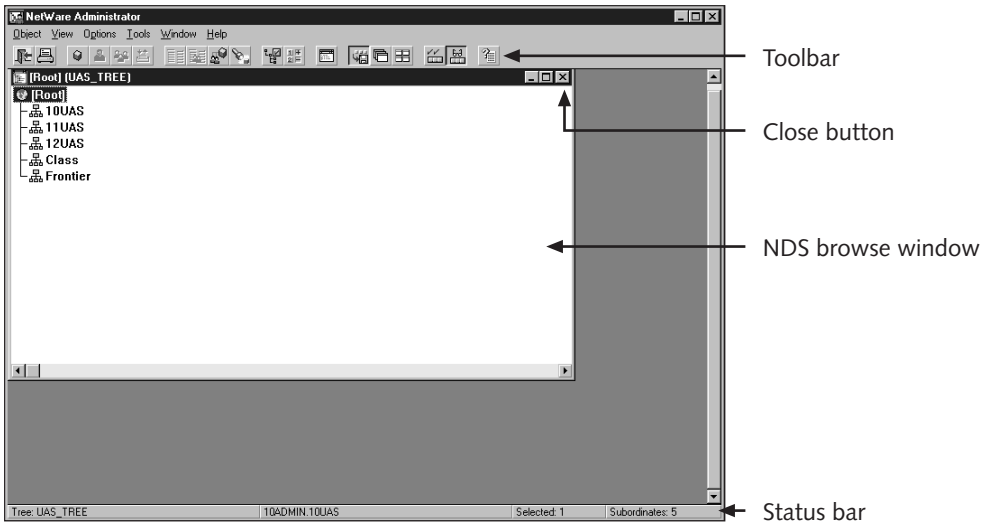

Figure 9-7 NetWare Administrator window

3. If the NWAdmin screen does not display your NDS tree by default, you can specify the tree by choosing **View** on the menu bar, and then choosing **Set Context**. Enter **[Root]** in the context field, and then click **OK**.
4. Double-click the root object, if necessary, to reveal your server's NDS tree, with organizational objects underneath the root and leaf objects (if they exist) underneath the organizational (container) objects. Proceed through the following steps to add objects to your NDS tree.
5. To create an organization, right-click the root object, then choose **Create**.
6. A list of objects appears. Scroll down the list, highlight **Organization**, and then click **OK**.
7. The Organization dialog box opens. Enter your Organization name, and then click **Create**. The newly created Organization appears in the NDS tree.
8. To create an object inside the Organization, right-click the Organization, then choose **Create** from the menu that appears.
9. The program displays a list of objects that you can choose to create within the Organization. Notice how many more options appear in this list than were shown in the list of objects you could create from the Root.

10. To create an Organizational Unit beneath your Organization, select the Organizational Unit object, then click **OK**. The Create Organizational Unit dialog box opens.
11. Enter the name of the Organizational Unit, and then click **Create**. To see the name of the newly created Organizational Unit in the NDS tree, double-click the Organization object.
12. To create a user belonging to your Organizational Unit, right-click the Organizational Unit, then choose **Create** from the menu. The program displays a list of objects you can choose to create within the Organizational Unit.
13. Press **U** to select the User object in the list of objects you can create.
14. Press **Enter** to create a User object.
15. The Create User dialog box appears, as shown in Figure 9-8. You are prompted to enter the user's ID and last name. These two fields are the only fields you must complete to create a user. Often, you will want to choose additional options, such as granting a home directory to the user or assigning a template to the user. Click **create** after entering the user's ID and last name.

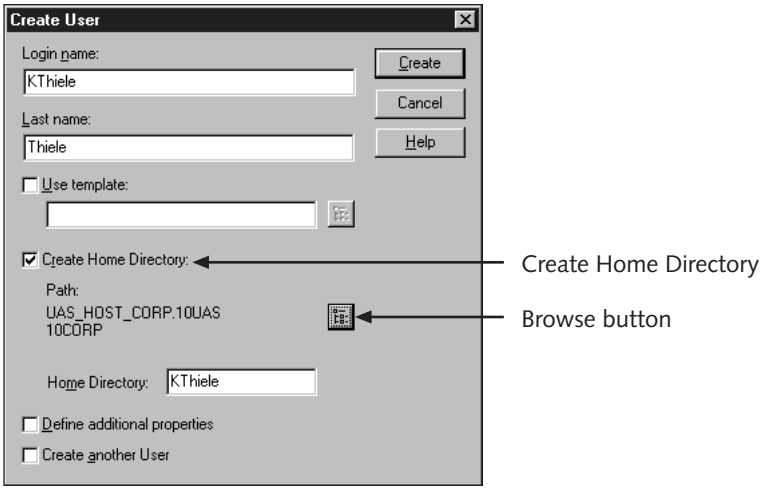

Figure 9-8 Create User dialog box

If you choose to establish a user's home directory when you create the user ID, that user will have all rights to his or her home directory by default. As a result, you do not have to assign Read, Write, Erase, or other rights for the user's home directory later. If you do not create a user's home directory when you create the user ID, and you later decide to grant a home directory to the user, you must manually assign rights before the user can save, change, or delete files in his or her home directory.

After you have created NDS objects, you may want to change their properties. For example, if one of your staff members changes her last name, you will want to change the last name property within her User object. To view or change the properties of any leaf object (such as a printer, user, template, or group), you can right-click the object in the tree, then choose Details from the menu that appears.

To modify the properties of a User object through NWAdmin:

1. Right-click the User object whose properties you want to modify, then choose **Details** from the menu that appears. Alternatively, you can double-click the User object to view its Properties dialog box.
2. The object's Properties dialog box appears. The right side of the properties dialog box contains a number of properties buttons. Click the button whose properties you want to change. For example, if you want to modify the user's password, click the **Password Restrictions** button. The Password Restrictions window appears, as shown in Figure 9-9.

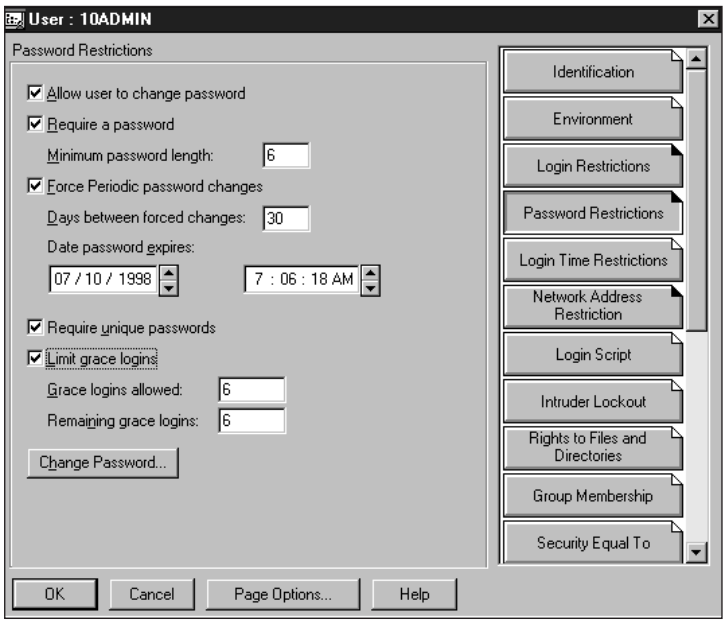

Figure 9-9 Password Restrictions dialog box

3. Change the properties as instructed by the Properties dialog box. For example, in the Password Restrictions window, you may choose to force users to change their passwords upon logging in, enforce a minimum length for passwords, or change a user's password.

To delete an NDS object through NWAdmin:

1. Right-click the object, then click **Delete** on the shortcut menu.
2. NWAdmin asks whether you really want to delete the object. Click **Yes** to confirm the deletion.

NWAdmin will not allow you to delete an object that contains leaf objects. If you want to delete a container object, you must delete its subordinate objects first. To do so, highlight the first object in the container to be deleted, hold down the Shift key, and then click the last object to be deleted. You should see the objects between the first and the last object highlighted. Press the Delete key. NWAdmin will ask you to confirm that you want to delete the group of objects.

The operations described in this section cover only a small fraction of NWAdmin's capabilities. In real-world day-to-day network operations, you will find that your most frequent use of NWAdmin will consist of viewing, modifying, and creating objects. In addition to carrying out these operations, you may manage other Novell programs, such as NetWare Distributed Printing Services, GroupWise, or ZenWorks from NWAdmin. You may also manage Windows 2000 resources if Windows 2000 servers are integrated into your NDS tree. Using NWAdmin, you can search for objects, move objects from one container to another, or assign templates or profiles to objects. In short, NWAdmin is your link to managing your NDS tree.

Internetworking with Other Operating Systems

In Chapter 8, you learned that both Novell and Microsoft have made great strides in enabling their network operating systems to interact. Microsoft has devised one solution (Gateway Services for NetWare), and Novell has created another, called **NDS eDirectory** for Windows NT/2000. The NDS eDirectory works with the NetWare 5.x operating systems and Windows NT or 2000 servers to enable Windows domains to appear as container objects in NWAdmin. In Novell's terminology, NDS eDirectory extends the schema to include Windows NT or 2000 resources. Windows NT and 2000 servers appear as server objects, and groups and users from Windows domains appear as NDS group and user objects, respectively. With NDS eDirectory enabled, users who require services from both Windows 2000 and NetWare servers can simply log on to the NDS tree, rather than logging on to both types of servers.

NDS eDirectory provides a simple solution to a network administrator's challenge of integrating Windows 2000 and NetWare. On Windows 2000 servers, an NDS eDirectory client and service must be installed and bound to the network cards. Once this tool is installed, the Windows 2000 server appears as a container object in the NetWare NDS tree when it connects to the network. Once the Windows 2000 server is an NDS object, it can be managed centrally through the NetWare Administrator utility. This ability makes the network administrator's job of managing mixed server environments much easier.

Realistically, you would probably use NDS eDirectory in a networking environment dominated by NetWare products or in an environment in which the complex structure of servers, users, locations, and so on demands the comprehensive management capabilities of NWAdmin. If most of your servers run Windows 2000 Server, using Microsoft's Gateway Services for NetWare, as described in Chapter 8, may make more sense.

On the client side, Novell provides client software specifically designed for Windows 2000, Windows NT, Windows 9x, OS/2, Macintosh, and UNIX clients. These packages come at no extra cost with the NetWare 4.x and 5.0 operating systems, or they can be downloaded from Novell's Web site.

CHAPTER SUMMARY

- Currently, several versions of NetWare are available. NetWare 3.x includes versions 3.1 through 3.2. Although these versions were introduced in the early 1990s, many have not been replaced with newer versions—a testament to their high reliability. Novell introduced NetWare 4.x in the mid-1990s. NetWare 4.x is more user-friendly and provides much better support for enterprise-wide networks containing multiple servers than NetWare 3.x.
- In 1998, Novell released version 5.0 of NetWare, which not only increases the extent and ease of network management, but also provides a network operating system based on the IP protocol. It uses the programming language Java for many of its interfaces and services. NetWare 5.x also offers better printer and file system administration than version 4.x does.
- Both NetWare 4.1 and 5.x use Novell Directory Services (NDS) to organize users, groups, servers, and other network resources. Both versions provide a graphical interface for managing network resources. In addition, both support integration with other network operating systems, Web services, multiple protocols, asset management, migration utilities, and software distribution.
- Novell provides extensive online support from its support Web site. The company also provides enhanced technical support to Certified NetWare Engineers (CNEs) through CDs and discounted calls to its help desk. In addition, a number of third-party discussion groups on the Web focus on NetWare products.
- NetWare is optimal for file and print sharing. It can run multiple services simultaneously and use multiple processors. Its modularity allows the network administrator to isolate some processes from others or change the priority of critical applications. NetWare does not require you to restart the server when you change its configurations, keeping service interruptions brief.
- NetWare offers native interoperability solutions for Macintosh-, DOS-, Windows-, OS/2-, and UNIX-based systems.

- NetWare may not suit every organization. If your organization depends heavily on enterprise-wide Microsoft solutions you may want to forego a NetWare purchase. If your technical staff prefers or demands a simple graphical interface, Windows 2000 Server may be a better choice. Although NetWare offers graphical interfaces for both management and console functions, its interfaces are less responsive or intuitive than Microsoft's graphical interfaces.
- At a minimum, your NetWare 5.x server should contain a Pentium processor, at least 64 MB RAM, a CD-ROM drive, a floppy disk drive, a hard disk with a DOS partition larger than 50 MB and a NetWare partition larger than 300 MB, a pointing device, and a NIC. In reality, your server will probably require more RAM and hard disk space than the minimum configuration suggested.
- To determine your NetWare server's requirements, you will want to consider the number of NetWare loadable modules (NLMs) used by each service. NLMs are routines that enable the server to run programs and services ranging from protocol support to Web publishing. Each NLM consumes some of the server's memory and processor resources (at least temporarily).
- You can add components to your NetWare server to enhance its fault tolerance and performance. The most popular additional components include multiple processors, more RAM, multiple NICs, fault-tolerant hard disks, a backup drive, and an uninterruptible power supply.
- In versions 5.x and higher, NetWare supports the use of as many as 32 processors on one server and uses symmetric multiprocessing, in which tasks are equally distributed among the processors.
- Whereas NetWare 4.x can use only physical memory, NetWare 5.x can use both virtual memory and physical memory.
- Like Windows 2000, NetWare uses 32-bit addressing to provide quick access to the physical memory. NetWare also allows you to run services in a separate memory area from the operating system, which prevents one rogue routine from taking the server down. Assigning a separate memory area to a service is known as running the service in protected mode. In this mode, the service and its supporting routines cannot harm critical server processes.
- Novell allows network administrators to adjust the server's use of memory in a number of ways. This flexibility can be both a blessing and a curse. If you change a setting in the wrong direction you can restrict the server's ability to send or transmit data efficiently. On the other hand, every environment will require some fine-tuning to maximize the use of memory and every organization will have its own memory needs.
- At the heart of NetWare lies the kernel, or the core of the operating system. NetWare's 32-bit kernel is responsible for overseeing all critical server processes. The program SERVER.EXE runs the kernel from a server's DOS partition. Typically, a

server will start from an AUTOEXEC.BAT file that launches SERVER.EXE; from that point forward, NetWare controls the machine's operations.

- The network administrator's primary interface to a NetWare server is the server console. Unlike Windows 2000, the NetWare server interface is not entirely graphical. NetWare 4.x uses only text-based server menus at the console. NetWare 5.x, allows you to access commands through either a text-based or graphical menu system. The graphical interface in NetWare 5.x is called ConsoleOne.
- Hundreds of NLMs are available for the NetWare operating system. In fact, developers can write their own NLMs for special purposes because Novell shares its operating system code. Most of the NLMs you'll ever need, however, will come with your server software or the additional utilities you install.
- NetWare's high-performance file system supports DOS, Macintosh, UNIX, OS/2, and Windows. Although DOS filenames are supported by default, you must load the proper NLMs on the server to gain support for other filenames. Once you have installed the necessary modules, Macintosh, Windows, UNIX, or OS/2 clients can read from the server as if the server were speaking their language. Because NetWare uses modules—rather than file systems—to support this type of access, file/directory size limitations and performance do not vary between NetWare volumes or servers.
- Like Windows 2000, NetWare uses volumes as the basis for organizing files and directories on the server. When you install NetWare, a volume called SYS is created automatically. At the time of installation, you may also choose to create additional volumes, such as DATA (for user data) or APPS (for shared applications).
- You should design a file system hierarchy that meets your performance, security, growth, and data sharing goals. Keep volume names short, simple, and descriptive. Plan carefully before establishing a server's volume and directory structure—once established, this structure is very difficult to change. If you are installing a NetWare network from scratch, you should consult resources for guidance on planning the volume and directory structure for your network.
- NetWare 4.x and 5.x both support file compression. Novell's compression is performed on a file-by-file basis, and the compression and decompression operations are transparent to the user. In both NetWare 4.x and NetWare 5.x, file compression is enabled by default during installation of the operating system.
- Block suballocation is a technique employed by NetWare for using hard disk space more efficiently. It enables files that don't fit neatly into a whole number of blocks to take up fractions of blocks, leaving the remaining fractions free for use by other data.
- A major development that Novell introduced with version 4.0 is NetWare Directory Services (NDS). NDS is a system of managing multiple servers and their resources, including users, volumes, groups, profiles, and printers. The NDS model is similar to Active Directory Windows 2000. In NDS, every resource is treated as a separate object with distinct properties. All objects can be centrally managed from a single interface.

- The NetWare installation process for the first server in a network generates the network's initial NDS. When adding subsequent servers or other resources to the network, you build upon this original NDS in a hierarchical fashion.
- Novell uses the analogy of a tree when describing this hierarchical layout. The NDS tree is upside-down, with a single root at the top and the leaves at the bottom. The root is created during the first NetWare (4.x or higher) server installation on the network. Once created, the root cannot be moved, deleted, or renamed.
- In the hierarchical NDS structure, the root leads to branches. These branches are called container objects (or organizational units) because their primary purpose is to logically subdivide and hold other objects that belong together, thus simplifying rights assignments, group login scripts, and so on. Container objects may organize resources by geographical location, department, professional function, security authorization, or other criteria significant to the particular network.
- Moving away from the root of the tree, branch objects lead to either more branch objects or leaf objects. A leaf object is an object in the NDS tree that does not contain other objects. Several kinds of leaf objects exist. You will typically deal with user-related leaf objects such as users, groups, profiles, templates, and aliases or printer-related objects such as printers, queues, and print servers. The place where an object belongs in an NDS tree is called its context.
- Novell uses the term schema to refer to the set of objects (such as user or printer) and their attributes in an NDS tree. The NDS schema serves as a reference for the logical design of your network, just as an architect's schematic drawing serves as the guiding reference for a building project.
- Before you insert the NetWare CD to begin installation of the operating system, you should consider many factors, including the organization's structure, function of the server, server hardware, applications, number of users, LAN architecture, and optional services (such as Web hosting). Once you have installed and configured the network operating system, changing its configuration may prove difficult and perhaps cause service disruptions for users.
- NWAdmin is a graphical interface that runs from a Windows workstation and enables network administrators to manage NDS objects. Through the use of drop-down menus and toolbars, NWAdmin simplifies the process of viewing, creating, changing, and deleting objects.
- The NDS eDirectory tool enables Windows 2000 domains to appear as container objects in NWAdmin. In Novell's terminology, NDS eDirectory extends the schema to include Windows 2000 resources. Windows 2000 servers appear as server objects, and groups and users from Windows 2000 domains appear as NDS group and user objects, respectively. With NDS eDirectory enabled, users who require services from both Windows 2000 and NetWare servers need to log in to only the NDS tree, rather than logging on to both types of servers.

KEY TERMS

block — A unit of disk space and the smallest unit of disk space that can be controlled by the NetWare system. Smaller blocks require more server memory.

block suballocation — A NetWare technique for using hard disk space more efficiently. Files that don't fit neatly into a whole number of blocks can take up fractions of blocks, leaving the remaining fractions free for use by other data.

caching — The process of saving frequently used data to an area of the physical memory so that it becomes more readily available for future requests. Caching accelerates the process of accessing the server because the operating system no longer needs to search for the requested data on the disk.

container objects — Logical subdivisions (or "branches") in NetWare's NDS tree that organize resources by geographical location, department, professional function, security authorization, or other criteria significant to the particular network.

context — A kind of road map for finding an object in an NDS tree. A context is made up of an object's organizational unit names, arranged from most specific to most general, plus the organization name. Periods separate the organizational unit names in context.

custom installation — A NetWare installation option that allows you to determine which services and programs are installed, among other things.

IntraNetWare — Another term for NetWare version 4.11, the version in which support for Internet services was first introduced.

kernel — The core of the NetWare operating system. NetWare's 32-bit kernel is responsible for overseeing all critical server processes. The program SERVER.EXE runs the kernel from a server's DOS partition.

Monitor — An NLM that enables the system administrator to view server parameters such as protocols, bindings, system resources, and loaded modules. In many cases, it also allows the system administrator to modify these parameters.

NDS eDirectory — Novell's integration tool for Windows 2000 networks. It works with the NetWare 5.x operating systems and Windows 2000 servers to enable the Windows 2000 domains to appear as container objects in NWAdmin.

NDS tree — A logical representation of how resources are grouped by NetWare in the enterprise.

NetWare 3.x — The group of NetWare versions that includes versions 3.0, 3.1, and 3.2.

NetWare 4.x — The group of NetWare versions that includes versions 4.0, 4.1, and 4.11.

NetWare 5.x—The group of NetWare versions that includes versions 5.0, 5.1, and 5.11.

NetWare Administrator utility (NWAdmin) — The graphical NetWare utility that allows administrators to manage objects in the NDS tree from a Windows workstation.

NetWare Directory Services (NDS) — A system of managing multiple servers and their resources, including users, volumes, groups, profiles, and printers. The NDS model is similar to Active Directory in Windows 2000. In NDS, every networked resource is treated as a separate object with distinct properties.

NetWare loadable modules (NLMs) — Routines that enable the server to run programs and services. Each NLM consumes some of the server's memory and processor resources (at least temporarily). The kernel requires many NLMs to run NetWare's core operating system.

object — A resource in NetWare's NDS tree. An object may represent a user, group, print queue, server volume, user template, mailbox, and so on. It may or may not contain other objects. All objects can be centrally managed in NDS.

organizational unit — See *container objects*.

protected mode — A manner in which NetWare runs services in a separate memory area from the operating system. Running services in protected mode prevents one rogue routine from taking the server down. As a result, the service and its supporting routines cannot harm critical server processes.

server console — The network administrator's primary interface to a NetWare server. Unlike Windows NT, the NetWare server interface is not entirely graphical. NetWare 4.x offers only text-based server menus at the console. NetWare 5.0 allows you to access commands through either a text-based or graphical menu system.

simple installation — A NetWare installation option in which the most popular installation options are chosen for you, and the installation takes less time than if you had chosen a custom installation.

typeful — A way of denoting an object's context in which the Organization and Organizational Unit designators ("O" and "OU," respectively) are included. For example, OU=Inv.OU=Ops.OU=Corp.O=Sutkin.

typeless — A way of denoting an object's context in which the Organization and Organizational Unit designators ("O" and "OU," respectively) are omitted. For example, Inv.Ops.Corp.Sutkin.

Review Questions

1. Which versions of NetWare support TCP/IP services such as Web site hosting?
   a. 3.x and 4.x
   b. 4.0 and 4.1
   c. 4.x and 5.0
   d. 5.x and 6.x
2. Which version of NetWare contains many services coded in the Java programming language?
   a. 3.11
   b. 3.12
   c. 4.11
   d. 5.0

3. How many processors can a NetWare 5.0 server support?
   a. 4
   b. 16
   c. 32
   d. 64
4. What is the minimum amount of RAM required for a NetWare 5.0 server?
   a. 8 MB
   b. 16 MB
   c. 32 MB
   d. 64 MB
5. Why might you want to install more than the minimum RAM required by NetWare 5.x?
6. Where can you go to find out about known bugs in NetWare?
   a. *www.help.novell.com*
   b. *www.support.novell.com*
   c. *www.novell.com/bugs*
   d. *www.novell.com/help*
7. How might NLMs provide better stability on your NetWare server?
   a. They can be loaded and unloaded without taking down the server.
   b. They can use multiple processors.
   c. They can prevent users from tampering with system files.
   d. They can be integrated with intrusion detection devices to recognize security breaches.
8. Which version of NetWare supports the use of virtual memory?
   a. 2.x
   b. 3.x
   c. 4.x
   d. 5.x
9. What stands at the very top of the NDS tree?
   a. root
   b. branch
   c. leaf
   d. trunk

10. If you decide to change the name of your NDS tree after you've installed NetWare, you can rename it through a server console command. True or False?
11. What is the name of the graphical server manager utility in NetWare 5.x?
    a. ServMan
    b. ConsoleOne
    c. NetManager
    d. NetMon
12. Which DOS command loads the NetWare operating system kernel?
    a. INSTALL
    b. LOAD KERNEL
    c. KERNEL.EXE
    d. SERVER.EXE
13. Which of the following file systems does NetWare not support?
    a. DOS
    b. NTFS
    c. UNIX
    d. Macintosh
14. What is the name of the volume created automatically when you install NetWare 5.x?
    a. DATA
    b. VOL1
    c. VOL2
    d. SYS
15. File compression is enabled by default during a NetWare 5.x installation. True or False?
16. Which server resource does block suballocation conserve?
    a. memory
    b. CPU
    c. hard disk space
    d. power draw
17. What is the purpose of a container object in an NDS tree?
    a. to logically subdivide objects in the tree
    b. to integrate a Windows 2000 domain
    c. to logically separate users according to usage patterns
    d. to logically group subnets

18. A user is an example of what kind of NDS object?
    a. tree
    b. root
    c. leaf
    d. branch
19. If a user's login ID is "james" and the user belongs to the "marketing" organizational unit, which is in turn part of the "Corporate" organizational unit within the "ABC" Organization, what is this user's context?
    a. james.marketing.corporate.ABC
    b. ABC.corporate.marketing
    c. O_ABC_OU_marketing_OU_corporate_U_james
    d. marketing.corporate.ABC
20. Which utility allows you to manage NDS objects?
    a. NDSCON
    b. NDSadmin
    c. NWAdmin
    d. NWManager
21. List five questions that you should answer before beginning a NetWare server installation.
22. After right-clicking an object within NWAdmin, which option should you choose to modify that object's properties?
    a. Details
    b. Properties
    c. More
    d. Tools
23. In a typeful context notation, how is a user object's container designated?
    a. CXT
    b. CN
    c. OU
    d. O
24. Why might you want to create an administrator-equivalent ID that isn't called "Admin"?
    a. for easier management
    b. for security purposes
    c. to share administrative rights among many users
    d. to enable remote administration

25. After a simple NetWare 5.x installation, what rights does the default group called PUBLIC have to the NDS tree?
    a. Supervisory
    b. Browse, Modify, Erase
    c. Browse, Modify
    d. Browse
26. In NWAdmin, you can grant users rights to save files in a directory. True or False?
27. In NetWare version 5.x, which command should you use to access the protocol and NIC configuration utility?
    a. inetcfg
    b. ipconfig
    c. netconfig
    d. nwconfig
28. What must the network administrator do in NWAdmin before he or she can delete a container object?
    a. delete all objects within the container
    b. rename the container
    c. move the container to the trash
    d. ensure that the container is not part of another container
29. Which Novell utility enables Windows 2000 servers to appear as objects in the NDS tree?
    a. NetWare Windows Gateway Services
    b. Windows 2000-NDS Gateway
    c. NDS eDirectory
    d. NetWare for Windows 2000
30. If you use NetWare's Windows 2000 integration tool, what type of an object will a Windows 2000 domain appear as in an NDS tree?
    a. container
    b. group
    c. server
    d. organizational unit

HANDS-ON PROJECTS

Project 9-1

For this project you will need only a pencil and paper.

Before you install your first NetWare server, or even work with objects in an NDS tree, you should have a good understanding of the organization of the NDS tree. This exercise will help you to conceptualize an NDS tree.

1. A city school district has five elementary schools, two middle schools, and one high school running a NetWare 5.1 network. Give the schools and the organization (root of the NDS tree) names.
2. Draw an NDS tree in which each type of school (elementary, middle, and high school) belongs to a separate container object.
3. Add two teacher IDs to one of the containers you created. Based on the names you gave to your containers and tree, write the users' names in typeful context under the user ID you assigned them underneath the users you added (you may want to refer to the examples of typeful context names given in this chapter).

Project 9-2

In this exercise, you will experiment with using commands from the NetWare prompt. With such commands, you can check which modules are running on your server, load new modules, and unload already running modules. For this project you will need a working NetWare 5.x server installed with no more than the basic operating system.

1. At the NetWare server console prompt, type **`modules`**. (If your server's screen does not show the prompt, press the **Alt+Esc** key combination until the screen with the prompt appears.) How many modules are loaded on your NetWare server?
2. Sometimes you will want to know whether a module is running, but with hundreds of modules on your server, you may not remember the module's name. In this case, you can simply look for all modules beginning with the same letter. To demonstrate, type **`modules c*`** at the NetWare system prompt. On a piece of paper, write the names of the NLMs running on your server that begin with the letter "c."
3. To view information about how the server is running, type **monitor** at the console prompt. Write down your server's CPU utilization data.
4. Press the **Alt+Esc** key sequence. What happens?
5. At the console prompt, type **`nwconfig`**. Look at the menu options. Which one will allow you to install an additional NetWare service? Which one will let you manage the protocols bound to the server's NIC(s)?
6. Press the **Alt+Esc** key sequence. What happens?
7. Display the monitor screen again.

8. Highlight **Connections** in the Available Options window, then press **Enter**.
9. How many users are connected to the server?
10. Press **Esc** to return to the main menu.
11. Press **Esc** again, highlight **Yes**, then press **Enter** to confirm that you want to exit the monitor screen.
12. Use the **Alt+Esc** key sequence to return to the nwconfig screen.
13. Press **Esc**. When prompted, confirm that you want to exit the nwconfig screen.
14. At the console prompt, type **`volumes`**, then press **Enter**. How many volumes are installed on your server? What are their names? What kind of file systems does each volume support?
15. As a network administrator, you will sometimes need to take the server down (for example, to repair a faulty memory module or to install a new NIC). This process can be accomplished by one simple command. To demonstrate, type **`down`**, then press **Enter**. What kind of message appears? Click **Yes** to confirm that you want to down the server. What happens?
16. After all of the processes have stopped running, type **`exit`**, then press **Enter**. At the DOS prompt, type **`dir`**. Which directory do you suppose contains the NetWare operating system?
17. Look at the machine's AUTOEXEC.BAT file by typing **`type c:\autoexec.bat`** at the DOS prompt. What commands are in the server's AUTOEXEC.BAT?
18. To start the NetWare server again, type **`server`**. Alternatively, you can restart the machine.

Project 9-3

In this exercise, you will experiment with using NetWare Administrator to create users and modify their object properties. For this project, you will need a Windows 2000 Professional workstation connected to a NetWare 5.x network. Your workstation should have (at least) the IPX/SPX protocol and the NetWare client (version 2.2 or higher) installed. You will also need to know the network's administrator-equivalent user ID and password.

1. From your Windows 2000 workstation, log on to the server as your administrator-equivalent user.
2. Double-click the **My Network Places** icon.
3. Find your server in the My Network Places window and double-click it. (You may need to navigate through the Novell Connections to find the server.)
4. Double-click your server's SYS volume.
5. Open the **PUBLIC** folder on the SYS volume.
6. Open the **Win32** folder.
7. Double-click the **NWADMN32.EXE** file. The NetWare Administrator utility (NWAdmin) loads.

8. Using the steps provided in the chapter as a guide, add two organizational units in the organization of your NDS tree, one called **ACCT** and another called **MKTG**.
9. Add two users to the ACCT container: **Arnold Thomas** and **Faye Bernstein**, making their user IDs be a combination of the first letter of the first name plus the last name. Give the users home directories as you create them.
10. Add two users to the MKTG container: **Debby Chang** and **Matt Winzer**, following the same naming convention you used for the ACCT users. Do not assign these users home directories.
11. Double-click the **AThomas** user icon. The user's Properties dialog box should appear.
12. Make sure that the **Identification** button on the right side of the user's Properties dialog box is selected. Enter the user's first and last name, plus his department, phone number, and location.
13. Click the **Password Restrictions** button from the right side of the user's Properties dialog box. The user's password restrictions properties appear.
14. Click **Change Password**, then type **nw5user** in the new password text box. Type the password again to confirm it.
15. Click **OK** to save your changes. You will return to the user's Properties dialog box.
16. Click **OK** to accept your changes. The user's Properties dialog box will close.
17. In the NWAdmin menu, click **Object**, and then click **Exit**.
18. Click **Start**, click **Shut Down**, click **Log off administrator** from the drop-down list, then click **OK**.
19. Log on to the NetWare 5.x server as **AThomas**, using the password you specified in Step 14.
20. Follow steps 2 through 7 to launch NWAdmin.
21. Double-click the **MKTG** container to see its contents.
22. Right-click the user **DChang**, then choose **Delete** from the menu that appears. Click **Yes** to confirm that you want to delete this account.
23. What happens? Why?
24. Exit NWAdmin, then log on as your administrator ID again.
25. Try deleting the user called **DChang**.
26. What happens? Why?
27. Close NWAdmin, then log on as **FBernstein**.
28. What kind of password prompt do you receive? Why?
29. Using Network Neighborhood, open the SYS volume of your NetWare server.
30. Double-click the **Users** folder.
31. What do you see? Why?

CASE PROJECTS

1. An office furniture manufacturer called Advanced Ergonomics Solutions (AES) asks you to help the company design a new network. The network managers plan to throw out the obsolete ARCNet system they have used for eight years and install new NetWare 5.1 servers. They do not know how many servers they need or how to organize the servers, users, and groups. AES has two offices in town. The corporate headquarters houses 100 users, including 20 users in Marketing, 20 users in Operations, 40 users in Research, and 20 users in Customer Service. The users in Research save confidential data that no one else in the company is allowed to see. You've been informed that the company plans to increase the headcount at headquarters fourfold within the next 18 months. AES's other office in town is located at a warehouse and includes only 10 shift workers. What recommendations can you provide to the network managers at AES about organizing their network? How many servers will they need? (More than one solution is possible.) Sketch your proposed NDS solution in tree form, beginning with the root object.
2. The network managers at AES have implemented the system that you recommended and they are very pleased. The only problem is that the performance on the Research server seems sluggish compared with the performance of the other servers. The researchers use database files that are nearly 200 MB large to hold their test results, and these files load excruciatingly slowly. The network managers wonder whether they should buy faster servers or change the system somehow. Realizing that you accepted all of the defaults when you installed the NetWare 5.1 operating system, what kinds of things would you check to ensure that performance is at its peak on their servers? What other recommendations can you give?
3. Now the network managers at AES have called you regarding an unrelated problem. One of the company's vendors has developed a chair stress simulation program that can be accessed from a network. AES researchers and customer service personnel are eager to start using it, but the vendor insists that the simulation program can run only on a Windows 2000 server. AES let the vendor bring in a Windows 2000 server on a test basis, but now users who want to access the program must log on to the network twice: once for NetWare servers, and once for the Windows 2000 server. What can you tell the network managers about integration between these two systems that might make sense in their organization?